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The pseudoscorpion family Garypidae (Pseudoscorpiones) of Taiwan: a new species in the newly recorded genus *Anchigarypus* and the first females of *Garypus wilsoni* and *Garypus sanasai*

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Abstract

Pseudoscorpions are a group of arachnids that inhabit various habitats, but only a few species occur in the intertidal zone, where their dispersal is presumably facilitated by ocean currents. In Taiwan, only two coastal species, *Garypus wilsoni* Lin & Chang, 2022 and *Garypus sanasai* Lin, Huang & Chang, 2022, have been formally recorded. In this study, we document the first record of the genus *Anchigarypus* Harvey, 2020, describe a new species, *Anchigarypus longimanus* **sp. nov.**, report its molting nest, and provide the first identification key for the species of *Anchigarypus* worldwide. We also provide the first descriptions of female specimens of *G. wilsoni* and *G. sanasai*.

Key Words

COI, intertidal, molting nest

Introduction

Pseudoscorpions are tiny arachnids with a body length of approximately 0.1–1 cm (Beccaloni 2009). They inhabit diverse habitats, such as leaf litter, under bark, beneath beetle elytra, and in shaded rocky environments, where they avoid direct sunlight. In coastal areas, several pseudoscorpion genera from different families can be found, such as *Anchigarypus* Harvey, 2020 (Garypidae), *Anagarypus* Chamberlin, 1930 (Garypidae), *Garypus* L. Koch, 1873 (Garypidae), *Nipponogarypus* Morikawa, 1955 (Olpiidae), and *Paraliochthonius* Beier, 1956 (Chthoniidae) (Lee 1979; Harvey et al. 2020; Jeong et al. 2024). These arachnids are often observed wandering along the coast at night.

The Pacific pseudoscorpion genus *Anchigarypus* comprises only three species (World Pseudoscorpiones Catalog 2025): *A. californicus* (Banks, 1909), *A. guadalupensis* (Chamberlin, 1930), and *A. japonicus* (Beier, 1952). The first two species occur in North America and Mexico, while the third species is found in Korea and Japan. Notably, there are no recorded occurrences of *Anchigarypus* in Taiwan or further south. These three species were previously assigned to *Garypus*, a widely distributed genus with 38 species (World Pseudoscorpiones Catalog 2025). Harvey et al. (2020), based on morphology and molecular phylogeny, proposed the new genus *Anchigarypus* and transferred the three species from *Garypus* to *Anchigarypus*. The genus *Garypus* was the only coastal genus previously recorded in Taiwan. To date, nine families, 10 genera, and 13 species of pseudoscorpions have been documented in the country (Lin et al. 2022; World Pseudoscorpiones Catalog 2025). Among these, *Garypus wilsoni* Lin & Chang, 2022 and *Garypus sanasai* Lin, Huang & Chang, 2022 were described based on single male specimens, while the females remained unknown.

In this study, we report several specimens of *Anchigarypus* discovered on the sandstone of the eastern coast

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of Taiwan. Morphological and molecular data indicate that these specimens represent a species new to science. We describe the new species, *Anchigarypus longimanus* sp. nov., provide detailed morphological descriptions, illustrations, photographs, COI (cytochrome c oxidase subunit I) sequences, and a key to the species of *Anchigarypus*. This discovery adds a new record of the genus to the pseudoscorpion fauna of Taiwan. In addition, we document the first female specimens of *G. wilsoni* and *G. sanasai* collected from the southern coast of the country.

Methods

Eight specimens of *Anchigarypus* and *Garypus* were collected by hand along the coastline of Fugang Geopark, Taitung County; Kararuran, Taitung County; and Hengchun, Pingtung County, at night. All specimens were preserved in 95% ethanol immediately after collection. Four legs on the left side were removed for DNA extraction. To observe the genital area, specimens were immersed in 10% lactic acid at room temperature for two days to clear them. After examination, the specimens were washed with distilled water and then preserved in 95% ethanol. The specimens were examined under a Nikon SMZ800N stereomicroscope and a Nikon Eclipse E200 compound microscope. Measurements were taken using a TOUPCAM E3ISPM12300KPA digital camera coupled with ToupView software (ToupTek Photonics). Photographs were taken using a BK Plus Lab system (Dun, Inc., Jacksonville, FL, USA) with a Canon EOS 7D Mark II camera equipped with an MP-E 65 mm macro photo lens. The images were captured using Capture One Pro 9.3 64-bit (v.9.3.0.85) and stacked with Zerene Stacker (Zerene Systems LLC 2018, Richland, Washington State, USA). Final editing was performed in Adobe Photoshop 2024 to remove artifacts and enhance image quality.

The QIAamp DNA Micro Kit (Qiagen, Hilden, Germany) was used to extract genomic DNA from two legs of the specimens, primarily following the manufacturer's protocol with slight modifications. The other two legs on the left side were preserved in 95% ethanol at 4 °C. Carrier RNA was added to buffer AL according to the instructions, and the DNA eluate was collected in 50 µL elution buffer. Polymerase chain reaction (PCR) targeting the mitochondrial cytochrome c oxidase subunit I (COI) gene was performed using the primers Chelicerate_R2 (Barrett and Hebert 2005) and CI-J-1718 (Simon et al. 1994) or LCO (Folmer et al. 1994). Amplification was carried out in 20 µL reactions under the following conditions: initial denaturation at 95 °C for 1 min; six cycles of denaturation at 94 °C for 40 s, annealing at 45 °C for 40 s, and extension at 72 °C for 1 min; followed by 30 cycles of denaturation at 94 °C for 40 s, annealing at 51 °C for 40 s, and extension at 72 °C for 1 min; and a final extension step at 72 °C for 5 min. The PCR products were visualized using 1.5% agarose gel electrophoresis and sequenced by Genomics BioSci & Tech. Co. Ltd. (New Taipei, Taiwan) using an ABI 3730X Genetic Analyzer. The resulting sequences were assembled in Geneious Prime 2023.2 and deposited in GenBank under accession numbers PV819807, PV819808, and PV819809.

The COI sequences of *Anchigarypus* and *Garypus* were downloaded from GenBank. Uncorrected *p*-distances between newly acquired specimens and GenBank sequences of the same genus were calculated using MEGA X (Stecher et al. 2020).

The type specimens are deposited in the pseudoscorpion collection of the National Taiwan University Museum of Zoology (NTUM-PSC). For morphological descriptions, we followed the terminology and measurements of Chamberlin (1931) and Harvey (1992). The following abbreviations are used for trichobothria on the chela. Fixed finger: *eb*, external-basal trichobothrium; *esb*, external-subbasal trichobothrium; *est*, external-subterminal trichobothrium; *et*, external-terminal trichobothrium; *ib*, internal-basal trichobothrium; *isb*, internal-subbasal trichobothrium; *ist*, internal-subterminal trichobothrium; *it*, internal-terminal trichobothrium. Movable finger: *b*, basal trichobothrium; *sb*, subbasal trichobothrium; *st*, subterminal trichobothrium; *t*, terminal trichobothrium.

Results

Family Garypidae Simon, 1879
Genus *Anchigarypus* Harvey, 2020

Anchigarypus longimanus sp. nov.

https://zoobank.org/E83402D7-EAE9-4DB5-9633-81675520613C

Figs 1–3

Type material. ***Holotype.*** Taiwan • female; Taitung County, Fugang Geopark; 22°47'37"N, 121°11'48"E; 15 Aug. 2021; W.Z. Tseng & T.K. Lin leg.; by hand; NTUM-PSC-0041 (former voucher no. HYPSC_00177). ***Paratype.*** Taiwan • male; same data as holotype; GenBank: PV819807; NTUM-PSC-0042 (former voucher no. HYPSC_00175).

Other material. 4 tritonymphs (HYPSC_00176 to 00180), same data as holotype.

Etymology. The specific epithet "*longimanus*" in Latin means long arms, i.e., the pedipalpal ratio of the new species is relatively longer than that of other members of *Anchigarypus*.

Diagnosis. The new species most closely resembles *Anchigarypus guadalupensis* from Mexico (Baja California) by the position of trichobothrium *est*, which is closer to *et* than *isb*. It differs from *A. guadalupensis* by the larger ratio of palpal femur (6.6 times longer than broad in female; 5.3 times in *A. guadalupensis*). It differs from *A. japonicus* with the slender palpal femur (6.6 times longer than broad in female and 6.4 times in male, 4.48 times longer than broad in male and 5.3 times in female in *A. japonicus*) and the position of trichobothrium *est*, which is approximately midway between *et* and *isb* in *A. japonicus*. It differs from *A. californicus* by the length-width ratio of

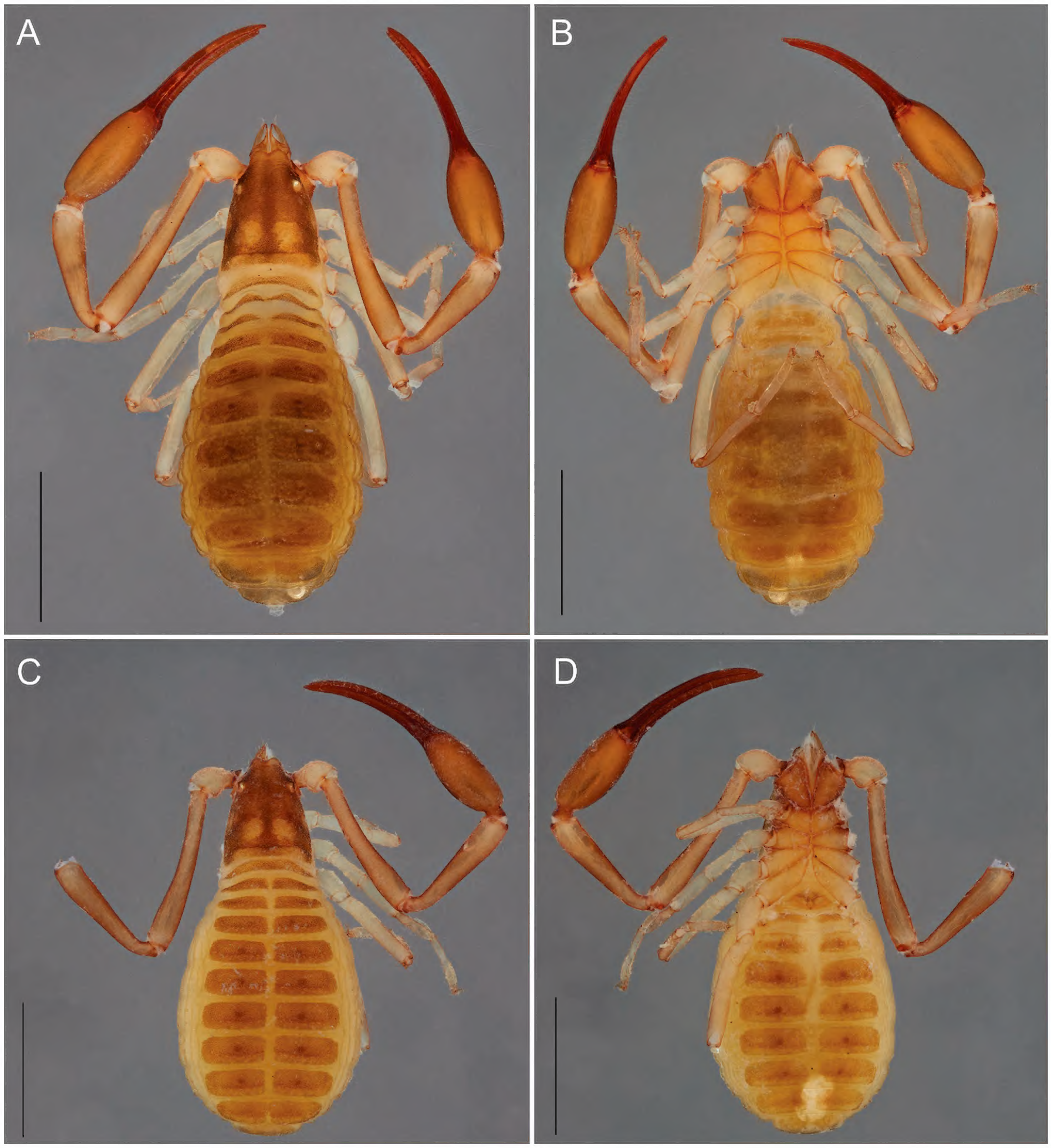

Figure 1. *Anchigarypus longimanus* sp. nov. **A.** Holotype female (NTUM-PSC-0043), dorsal view; **B.** Holotype female (NTUM-PSC-0043), ventral view; **C.** Paratype male (NTUM-PSC-0042), dorsal view; **D.** paratype male (NTUM-PSC-0042), ventral view. Scale bars: 1 mm.

palpal femur (4.0–4.8 times longer than broad in female *A. californicus*; 6.6 times in *A. longimanus* sp. nov.) and the position of trichbothrium *est*, which is approximately midway between *et* and *isb* in *A. californicus*.

Description. Color (Fig. 1): Carapace dark brown with two posterior pale-yellow dots; abdomen pale yellow, tergites yellow-brown, with brown medial marking; pedipalp linen, with dark-brown chela.

Chelicera: hand with 5 setae; movable finger with 1 short seta near galea; all setae acuminate; galea (Fig. 2E) present, with 3 distal, 2 lateral rami; fix finger with 3 small teeth, 1 dorsal basal lyrifissure; serrula exterior with 26 blades; serrula interior with 16 blades; rallum with 3 blades; lamina present.

Pedipalp (Fig 2A, B): Long, slender, surface lightly granular, chelal hand granular, both fingers smooth; setae very tiny; trochanter 2 times longer than broad; femur long and slender, without dorsal tactile setae, 6.41 times longer than broad; patella cylindrical, basal slimmer than distal, small lyrifissures situated on basal dorsal surface 4.2 times longer than broad; chelal hand ovoid, chela with pedicel 6.78 times longer than broad, chela without pedicel 6.48

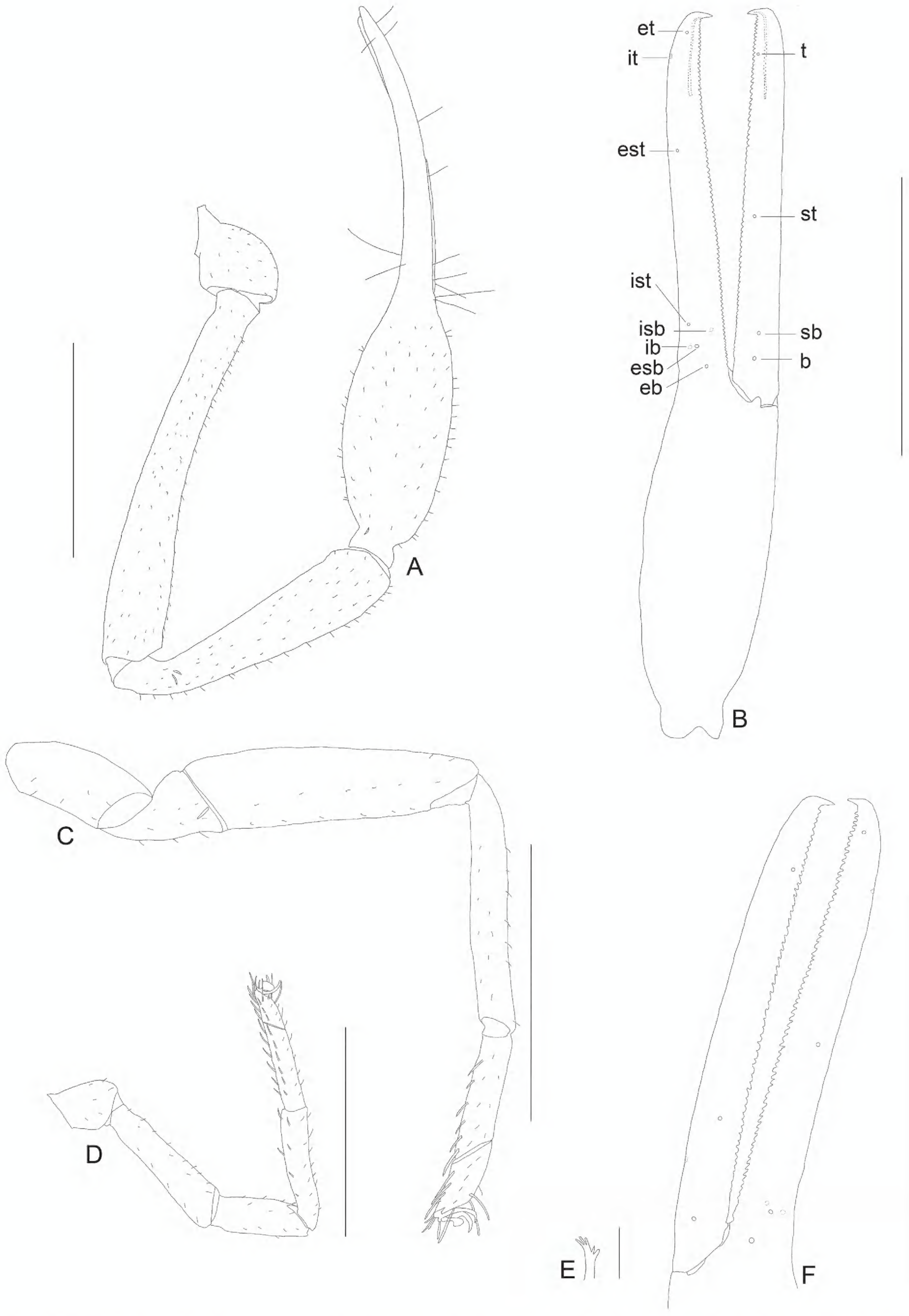

Figure 2. *Anchigarypus longimanus* sp. nov. (NTUM-PSC-0043). **A.** Left palp, dorsal view; **B.** Left chela, lateral view; **C.** leg IV, ventral view; **D.** Leg I, ventral view; **E.** Galea, dorsal view; **F.** Right chela, lateral view, tritonymph (HYPSC_00176). Scale bars: 1 mm (**A–D, F**); 0.1 mm (**E**).

Figure 3. Habitats at the type locality of *Anchigarypus longimanus* sp. nov. **A.** The nests of *Anchigarypus longimanus* sp. nov.; **B.** The sandstone with the nest of *Anchigarypus longimanus* sp. nov.; **C.** Habitat of *A. longimanus* sp. nov. Red arrow indicates the location from which the photo in **B.** was taken. Photo credit: Jyh-Jong Chern.

times longer than broad, movable finger 0.59 times longer than chelal hand. Both fingers curved in the lateral view, surface of both fingers smooth, venom apparatus present in both fingers, terminating nodus ramosus midway between *et* and *est* in fixed finger, between *t* and *st*, one-fourth distance from *t* in movable finger; fixed finger with 8 trichobothria, movable finger with 4 trichobothria: *eb*, *esb*, and *ist* in a straight row at basal fixed finger, *ib* and *isb* situated upon and below the row, *it* 4.6 times closer to *et* than to *est*; *sb* on movable finger 4.5 times closer to *b* than to *st*; fixed finger with 77 triangular retrorse teeth; movable finger with 73 triangular retrorse teeth; without microsetae near *b*, *t*, or *et*.

Cephalothorax: Carapace sub-triangular; 1.17 times longer than broad; epistome absent, anterior margin indented medially; anterior and posterior furrow present; tiny straight setae, rough cuticle; with two pairs of eyes situated on tubercle; 12 lyrifissures on the surface; Manducatory process with 4 apical setae and 16 additional setae; setal formula of coxae I–IV: 9: 7: 9: 13.

Legs (Fig. 2C, D): Metatarsi and tarsi of all legs not fused, metatarsi 2.26 times longer than tarsi in Leg I, 1.65 in leg IV; claw smooth, arolium not divided, shorter than claw.

Abdomen: Tergites divided; setae very small and in single row; chaetotaxy of tergites I–XII 6: 6: 4: 6: 10: 8: 10: 15: 14: 12: 6: 2; chaetotaxy of sternites II–XII 24: 13: 8: 8: 12: 9: 9: 9: 6: 4: 2; pleural membrane plicate.

Genital area: **Female**, anterior genital operculum with 8 setae with several lyrifissures, posterior with 10 setae in a row; 1 pair of lateral cribriform plates and 1 median cribriform plate divided into two major platelets. **Male**, anterior genital operculum with 25 setae and posterior with 14 setae.

Dimensions (in mm): **Female** body length (excluding chelicerae) 3.97. Chelicera 0.40/0.21; movable finger length 0.28. Pedipalp: trochanter 0.825/0.41; femur 1.99/0.31; patella 1.48/0.35; chela with pedicel 2.67/0.42; chela without pedicel 2.58 long; hand without pedicel 1.12 long; movable finger length 1.53. Carapace 1.29/1.10; anterior eye 0.11; posterior eye 0.11. Leg I: femur 0.71/0.16; patella 0.43/0.19; tibia 0.54/0.11; metatarsus 0.34/0.11; tarsus 0.15/0.11. Leg IV: femur + patella 1.25/0.21; tibia 0.92/0.14; metatarsus 0.43/0.12; tarsus 0.26/0.12.

Male Body length (excluding chelicerae) 3.95. Chelicera 0.26/0.20; movable finger length 0.22. Pedipalp: trochanter 0.52/0.36; femur 1.85/0.28; patella 1.45/0.33; chela with pedicel 2.78/0.41; chela without pedicel 2.66 long; hand without pedicel 1.17 long; movable finger length 1.57. Carapace 1.17/0.91; anterior eye 0.08; posterior eye 0.11. Leg I: femur 0.65/0.16; patella 0.39/0.18; tibia 0.51/0.13; metatarsus 0.33/0.10; tarsus 0.21/0.10. Leg IV: femur + patella 1.16/0.24; tibia 1.01/0.13; metatarsus 0.49/0.11; tarsus 0.26/0.11.

Remarks. The new species represents the fourth species of the genus and the second species recorded in Asia. Specimens of different stages of *A. longimanus* sp. nov. were collected from the same sandstone at night. The nests were found on the sandstone (Fig. 3), with four chambers within a 9 cm^2 area. One large chamber, with a diameter of about 1 cm, and three smaller chambers, each with a diameter of about 0.5 cm, were observed. Two of the chambers were adjacent to each other. A dead individual was found in the largest chamber, and a pair of palps was found in the chamber next to it.

Genus *Garypus* L. Koch, 1873

Garypus wilsoni Lin & Chang, 2022

Figs 4, 6

Materials examined. Taiwan • female; Pingtung County, Hengchun, Shadao; 21°54'43"N, 120°50'50"E; 03 Dec. 2021; J. J. Chern & U. Ong leg.; by hand; GenBank: PV819809; NTUM-PSC-0043 (former voucher no. HYP-SC_00186).

Description. Color in ethanol, chelicera, pedipalp, carapace similar with male, except coxae chaetotaxy I–IV: 7:7:10:22.

Genital area: anterior genital operculum with 20 setae, with two lyrifissures on the second row of setae posterior with 7 setae in a row; with a pair of lateral cribriform plates, and a median cribriform plate divided into two major platelets.

Abdomen: similar with male except for tergites chaetotaxy I–XII: 8: 9: 11: 6: 5: 9: 16: 10: 12: 10: 12: 2; sternites chaetotaxy IV–XII: 10: 11: 16: 10: 15: 13: 11: 5: 2.

Pedipalp: similar with male, *t*, *st* close to the edge of the finger, but *ib* closer to *isb* than to *esb*.

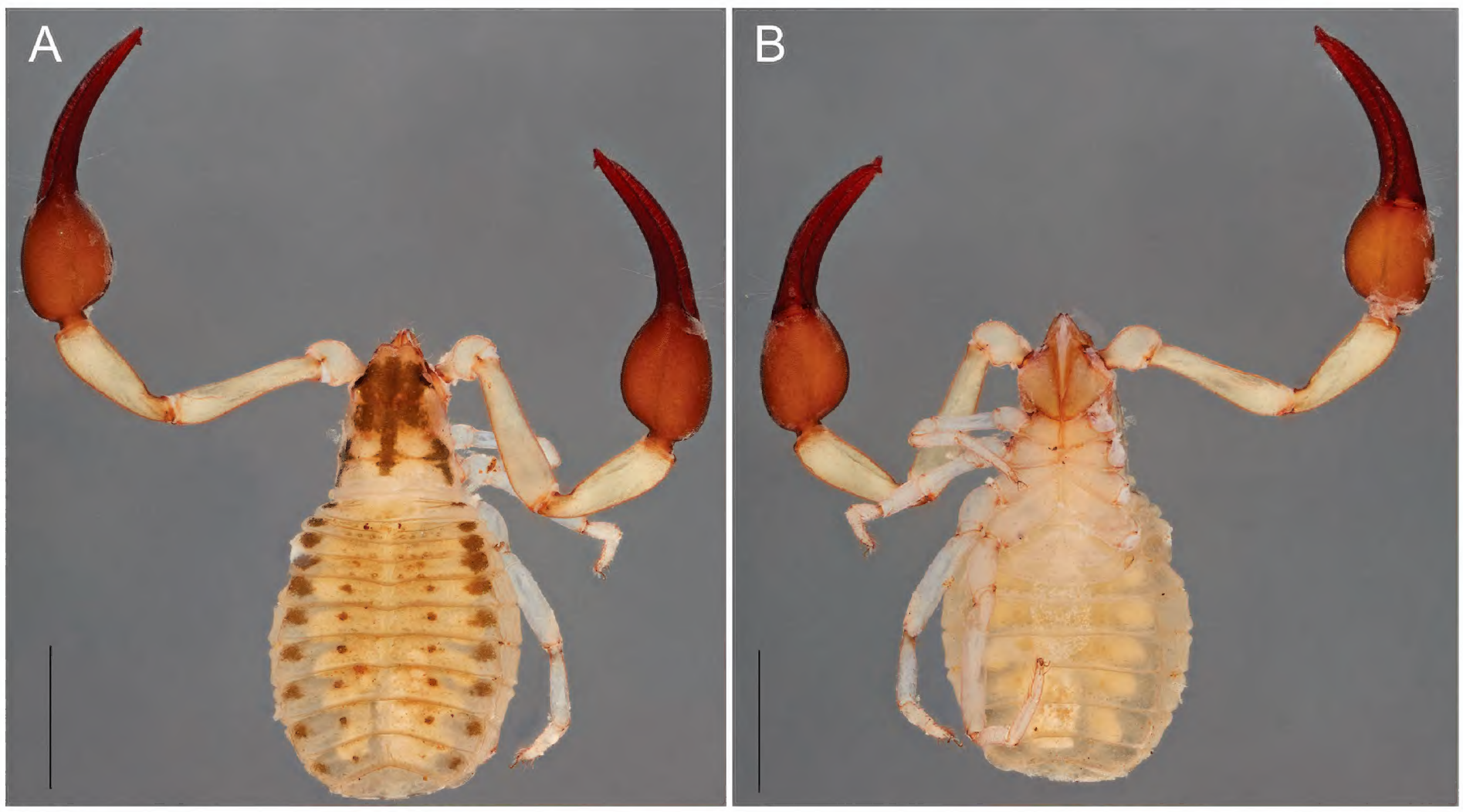

Figure 4. Female specimen of *Garypus wilsoni* (NTUM-PSC-0043). **A.** Dorsal view; **B.** Ventral view. Scale bars: 1 mm.

Dimensions (in mm): Body length (excluding chelicerae) 5.08. Chelicera 0.37/0.22; movable finger length 0.35. Pedipalp: trochanter 0.68/0.47; femur 1.76/0.44; patella 1.54/0.49; chela with pedicel 2.78/0.41; chela without pedicel 3.28 long; hand without pedicel 1.30 long; movable finger length 2.07. Carapace 1.62/1.46; anterior eye 0.15; posterior eye 0.12. Leg I: femur 0.61/0.15; patella 0.51/0.22; tibia 0.57/0.17; metatarsus 0.35/0.14; tarsus 0.27/0.14. Leg IV: femur + patella 1.26/0.23; tibia 0.87/0.15; metatarsus 0.41/0.15; tarsus 0.26/0.11.

Remarks. The female specimen of the species was collected from a coastal site located 24.3 km in a straight line from the type locality, thereby extending the distributional range of *G. wilsoni*.

Garypus sanasai Lin, Huang & Chang, 2022

Figs 5, 6

Materials examined. Taiwan • female; Taitung County, Taitung City, Jialulan; 22°48'18"N, 121°11'53"E; 17 Feb. 2024; C. C. Hsieh leg.; by hand; GenBank: PV819808; NTUM-PSC-0044 (former voucher no. HYPSC_00322).

Description. Color in ethanol, pedipalp, carapace, and chelicera similar to male, except galea with 6 rami, 5 rami at distal, 1 at lateral.

Coxae chaetotaxy I–IV: 8:9:14:19.

Genital area: anterior genital operculum with 15 setae, with one lyrifissure on the first row of setae, one lyrifissure on the second row of setae, posterior with 8 setae in a row; with a pair of lateral cribriform plates and a median cribriform plate divided into two major platelets.

Abdomen: similar with male except for tergites chaetotaxy I–XII: 8: 10: 10: 15: 12: 12: 11: 11: 10: 10: 8: 2; sternites chaetotaxy IV–XII: 10: 10: 16: 10: 10: 12: 10: 6: 2.

Pedipalp: similar with male, *ist* and *isb* on the same horizontal plane, *ib* between *isb* and *esb*.

Dimensions (in mm): Body length (excluding chelicerae) 6.24. Chelicera 0.43/0.26; movable finger length 0.43. Pedipalp: trochanter 0.73/0.49; femur 1.83/0.42; patella 1.55/0.44; chela with pedicel 3.34/0.89; chela without pedicel 3.29 long; hand without pedicel 1.40 long; movable finger length 1.90. Carapace 1.52/1.41; anterior eye 0.12; posterior eye 0.10. Leg I: femur 0.75/0.23; patella 0.42/0.23; tibia 0.62/0.17; metatarsus 0.39/0.14; tarsus 0.32/0.14. Leg IV: femur + patella 1.50/0.28; tibia 0.94/0.20; metatarsus 0.41/0.14; tarsus 0.33/0.14.

Remarks. The type locality of the species is Lüdao Island, which is 30 km away from Taiwan Island. The record of the female thus extends the known distribution range of *G. sanasai*. The sample was found under the rocks near vegetation and soil.

Uncorrected *p*-distance

Among the new species and the two described species, the inter-specific distances range from 8.2% to 18.0% (Table 1). Notably, a COI sequence (GenBank accession no. LC010873) of an unknown *Anchigarypus* specimen from Ishigaki Island of Okinawa, Japan, is only 2.8% different from the new species in Taiwan. As for *Garypus*, the COI sequences of both female specimens reported in this study are 100% identical to the two holotypes of the respective species (Table 2).

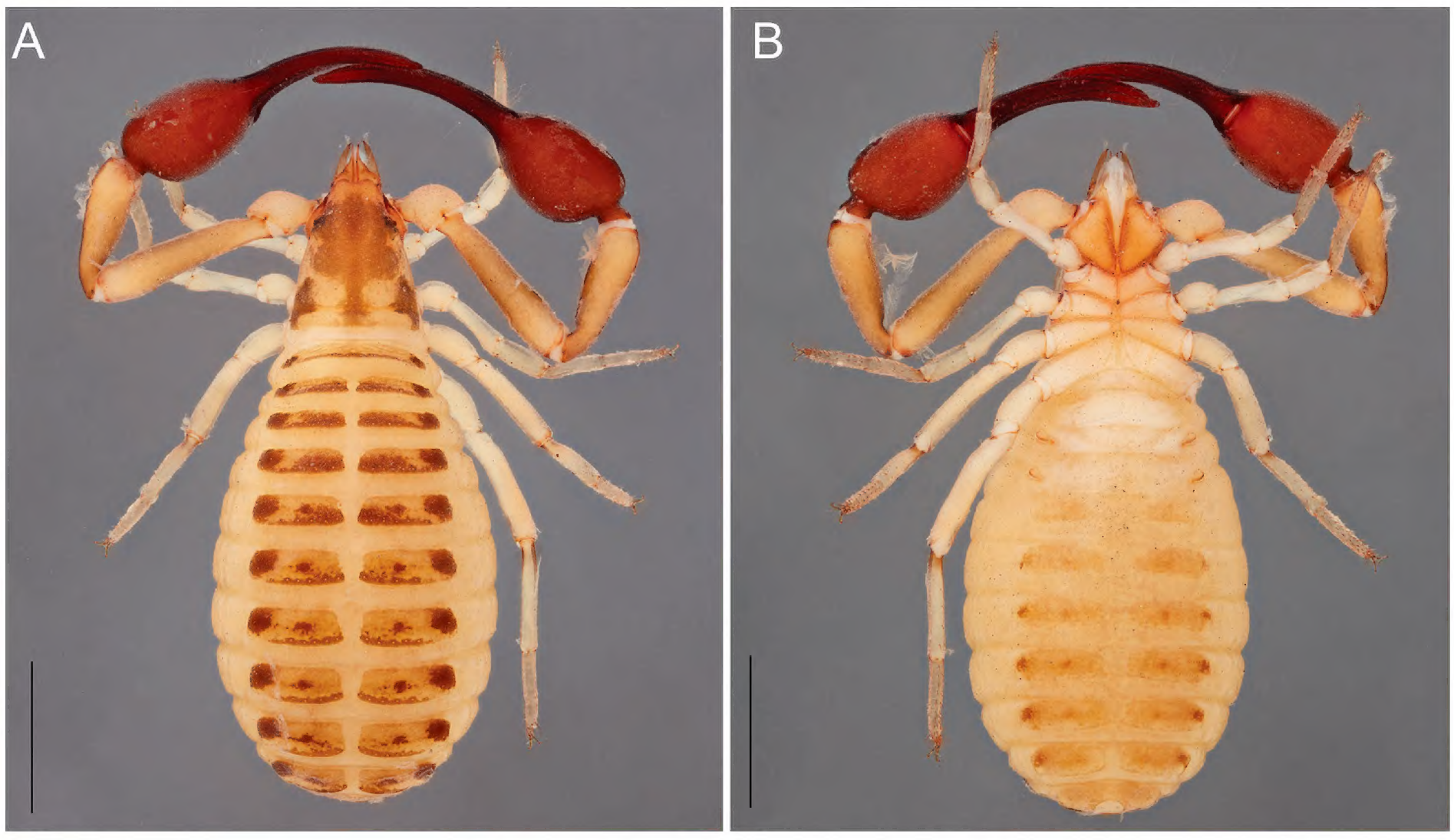

Figure 5. Female specimen of *Garypus sanasai* (NTUM-PSC-0044). **A.** Dorsal view; **B.** Ventral view. Scale bars: 1 mm.

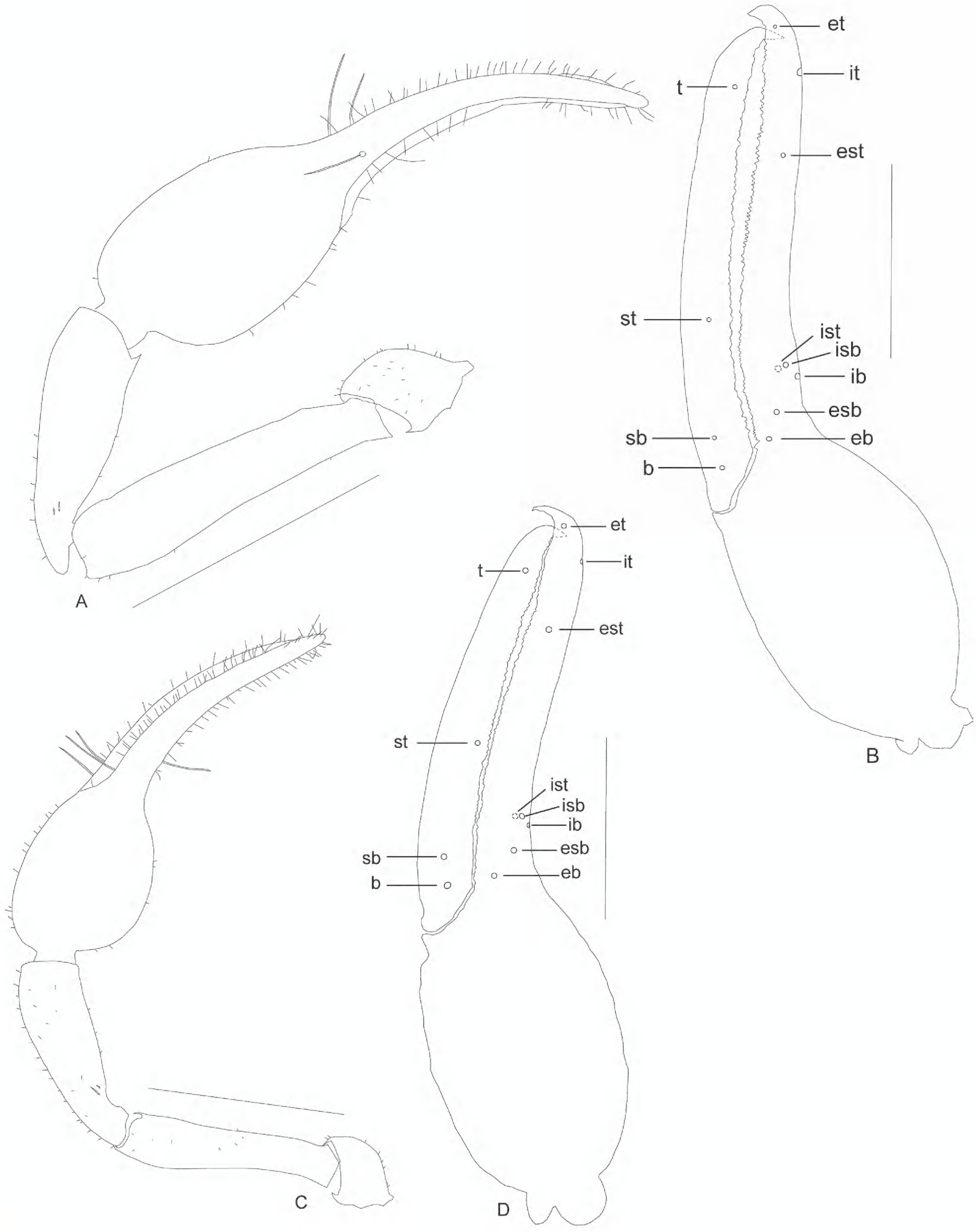

Figure 6. Left pedipalp of *Garypus*. **A.** Left pedipalp, dorsal view, female of *G. wilsoni* (NTUM-PSC-0043); **B.** Chela lateral view of *G. wilsoni* (NTUM-PSC-0043); **C.** Left pedipalp, dorsal view, female of *G. sanasai* (NTUM-PSC-0044); **D.** Chela lateral view of *G. sanasai* (NTUM-PSC-0044). Scale bars: 1 mm.

Table 1. Uncorrected *p*-distance between *Anchigarypus* specimens based on the COI gene.

	A. californicus **MN058668**	***A. longimanus*** **sp. nov. HYPSC_00175**	***A.*** **sp. Ishigaki LC010873**	***A. japonicus*** **LC010841**
A. longimanus **sp. nov. HYPSC_00175**	0.151			
A. **sp. Ishigaki LC010873**	0.161	0.028		
A. japonicus **LC010841**	0.180	0.100	0.103	
A. japonicus **MN058688**	0.159	0.082	0.093	0.044

Table 2. Uncorrected *p*-distance between *Garypus* specimens of Taiwan based on the COI gene.

	G. sanasai **holotype, male**	***G. wilsoni*** **holotype, male**	***G. wilsoni*** **female**
G. wilsoni **holotype, male**	0.0719		
G. wilsoni **female**	0.0718	0.0000	
G. sanasai **female**	0.0000	0.0719	0.0717

Key to the species of *Anchigarypus*

1 Trichobothria *st* situated midway between *t* and *sb*.....*A. japonicus*
– Trichobothria *st* closer to *sb* than to *t*..... 2
2 Trichobothria *est* situated midway between *et* and *isb*.....*A. californicus*
– Trichobothria *est* closer to *et* than to *isb*..... 3
3 Palpal femur 6.4–6.6 times longer than broad, body length around 3.95 mm.....*A. longimanus* sp. nov.
– Palpal femur 5.3 times longer than broad, body length around 5.61 mm.....*A. guadalupensis*

Discussion

Integrating both morphological and molecular data, this study reports the first record of the genus *Anchigarypus* in Taiwan and describes the first new species of the genus since 1952. The COI *p*-distances between the two described species, *A. japonicus* and *A. californicus*, and *A. longimanus* were higher than the 7% "threshold" interspecific distance reported for Garypidae (Harvey et al. 2020; Lin et al. 2022), supporting the conclusion that the specimens found in Taiwan are distinct from *A. japonicus* and *A. californicus*.

The GenBank COI sequence with low genetic divergence from the new species *A. longimanus* originated from an *Anchigarypus* sample collected on Ishigaki Island, approximately 250 km from the type locality of *A. longimanus*. Unfortunately, the specimen was lost during the Great East Japan Earthquake in 2011 (K. Yahata, personal communication 2021), making it impossible to confirm the identity of the Ishigaki sample. Nonetheless, the low COI *p*-distance between *A. longimanus* and the Ishigaki sample – much lower than the interspecific distance reported for Garypidae (7–17%; Harvey et al. 2020; Lin et al. 2022) – suggests that the lost Ishigaki specimen might have been *A. longimanus*.

At the type locality of *A. longimanus*, four silken chambers were found under the sandstone. A molt was recovered from the largest chamber, while a pair of palps was found in the smaller chamber adjacent to it. However, the pair of palps in the smaller chamber appeared smaller than the molt. We speculate that pseudoscorpions at different developmental stages coexisted on the sandstone. This observation aligns with similar findings in other coastal species, where multiple silken chambers and molts have been documented in shared habitats. For example, 124 chambers belonging to the pseudoscorpion *Neobisium maritimum* (Leach, 1817), a species of Neobisiidae, were found on the same stone (Gabbutt 1962). Similarly, Sato (2021) found 14 molt nests of *A. japonicus*, containing the molts of both adults and nymphs, in stone cracks.

Regarding the genus *Garypus*, the discovery of female specimens expands our knowledge not only of the morphology but also of the distribution of the two species. For *G. wilsoni*, the COI sequence of the female specimen was identical to that of the holotype, while the geographic distance between the two specimens is about 24.3 km. Additionally, we discovered a female specimen of *G. sanasai* on the coast of Taiwan, whereas the type locality of the species is on Lüdao, an island about 30 km away. The COI sequence of the female specimen was identical to that of the holotype from Lüdao, suggesting that *G. sanasai* lacks geographic genetic structure. This could indicate that the species has better dispersal capabilities than soil-dwelling species, which tend to show higher geographic structure (Muster et al. 2021; Just et al. 2023). The dispersal mechanism of *G. sanasai* remains unknown. Lee (1979) proposed that maritime pseudoscorpions may rely on avian dispersal and driftwood. Given the presence of driftwood at the collection site of the female *G. sanasai*, it is possible that the species disperses via driftwood. However, since the sampling site is located near a port with daily boat traffic to Lüdao, human activity may also play a role in the dispersal of the species.

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